Dr. Bruce Kaiser XRF Analysis

In the heading "Caretaker" I have briefly explained why I was looking for the XRF analyses.

In my research, I became aware that a handheld XRF-devise was available from the Bruker Company; the latest version of that instrument was the Tracer III SD. Fortunately a Major University in the South-East did have that instrument. They informed me that if I brought Catherine Howard in Stained Glass to their laboratory, analysis could be performed with the Tracer III SD and so it happened.

A few days later I received the test results.

Not a chemist by profession, but still having some knowledge about the basics of the organic and inorganic chemistry, I do understand how XRF works. Also I have a basic understanding of the errors that can occur when the settings of the instrument are not properly met for a specific application. In short, analyzing scrap metal is quite different from analyzing stained glass.

Hence, when I started to examine the data from the University, I realized that comparing those numbers with the data from Dr. Robert H. Brill's "CHEMICAL ANALYSES of EARLY GLASSES" Volume 2 would be a monumental task considering the complexity of the glass compositions. To make it worse, I found an unexplainable discrepancy in the elemental data.

Feeling stuck, I searched for options at the Bruker website and became aware that the Tracers were developed by Dr. Bruce Kaiser. We have a saying in Holland: "If you don't shoot, you always miss". With that in mind, I contacted Dr. Bruce Kaiser by email and explained my "what, why and now what".

In regards with this adventure, it was the best thing I ever did. Dr. Bruce Kaiser answered promptly and very comprehensive but most educational as well. He debunked right away some of my misconceptions and included some "light" reading for better understanding of the principles of XRF. We exchanged a few more emails clarifying some more details, whereby Dr. Bruce Kaiser told me that Bruker does not have a loan/rent program for the Tracer III SD but in case I could take Catherine Howard in stained glass cross country, he would be happy to do the analysis in his lab. So again I travelled with Catherine Howard in stained glass but now to the West Coast to have it analyzed.

Meeting Dr. Bruce Kaiser in person was a real delight. After all, a lot of world famous people have the tendency to become distanced from the hoi polloi. Definitely not the case with Dr. Bruce Kaiser. Needless to say that we had a really good time.

A few days later I received his report. It became crystal clear that an intrinsic knowledge of glass is the key to the interpretation of XRF data. These are the net numbers of photons from each element in 60 seconds:

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vest scana-0002 455	1022	159	32	2206	12	45	304	880	0	516	61	25	7039	451	764	242	102	545	29	5482
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vest scana-0004 433	1232	135	44	2111	29	33	256	946	-2	507	80	21	6705	378	748	201	163	488	30	5361
vest scana-0005 444	1204	223	15	2134	43	9	287	914	-1	514	61	35	6837	227	817	206	67	484	68	5506
vest scana-0006 364	1127	123	29	2124	4	7	277	881	0	528	54	3	6816	366	721	199	107	486	57	5499
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vest scana-0009 224	954			2138	9	22			36	495	50		6693	273	824	175	171	404	22	5396

Dr. Bruce Kaiser was well aware that representation of data in this format is impossible to understand for most. Therefore he used bar graphs to make it easier for us, common folks. In the next pages he gives an overview of the glasses as they were used through the centuries. With bar graphs he shows how much of the elements like Arsenic (As), Chromium(Cr), Manganese(Mn), Copper(Cu), iron(Fe), Lead(Pb), and Zinc(Zn) are present in the various pieces of glass.

He then describes how the blue background has a high concentration of Copper on front and back, indicating that the glass is true blue glass and not stained blue. After that he gives a brief explanation as to the use of Silver Stain for the color yellow. His graph shows a high concentration of Silver(Ag) on the medallion.

Dr. Bruce Kaiser comes to the most important aspect of the analysis.

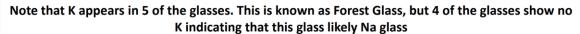
Composition, manufacture and distribution

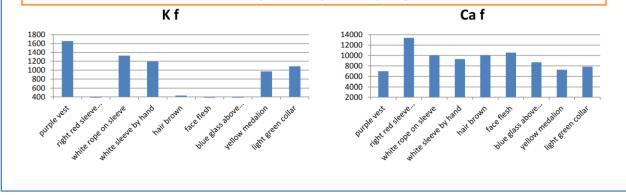
Prior to c.1000, most coloured glass was of a soda-lime-silica composition. In Northern Europe soda glass was eventually almost totally superseded by potash-lime-silica glass (Forest glass). Forest glass continued to be used in stained glass for the duration of the medieval period until soda glass again began to be used in the 16th century.

The potash (K_2O) found in Forest Glass was derived from wood ash. In *De Divers Artibus*, Theophilus describes the use of beech wood as the preferred source of ash. Other plant matter, such as bracken, was also used.^{[13} As well as containing potash, beech ash comprises an assortment of compounds including iron and manganese oxides, which are particularly important for generating colour in glass.

Medieval stained glass panels could be created either by the cylinder blown sheet or crown glass (window) method.

Forest glass was manufactured in Burgundy and Lorraine near the Rhein; in Flanders; and in Normandy, in the Seine and Loire Valleys. It was distributed throughout mainland north-west Europe and Britain in the form of ready-made sheets. The application of painted decoration to and final shaping of the sheets was carried out at glass working centres close by the final destination of the glass.





After his explanation of differences between Forest glass and Soda lime glass, this image shows on the left side that some of the glass contains Potassium (K) "Kalium" while it's absent in other pieces. It is undisputable that both kinds of glass were only used in the transition period during the first part of the 16th. century.

His conclusions draw some interesting facts. Indeed there is only one known stained glass artwork attributed to Hans Holbein Jr. at the Getty Museum as:

"A Premonstratensian Canon"

https://www.getty.edu/art/collection/objects/220332/possibly-after-hans-holbein-the-younger-a-premonstratensian-canon-swiss-about-1520/

Moreover, only a few stained glass artworks from his father, Hans Holbein Sr, are known and they are among the most extremely beautiful stained glass windows ever made.